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## PROVISIONAL APPLICATION COVER SHEET

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This is a request for filing a PROVISIONAL APPLICATION under 37 CFR 1.53(b)(2)

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## TITLE OF THE INVENTION (280 CHARACTERS MAX.)

Novel Materials And Methods Useful In Producing OLED's

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## ENCLOSED APPLICATION PARTS (Check all that Apply)

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2 Oct 03

Respectfully submitted,

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Enclosures

:yw

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## Novel Materials And Method Useful In producing OLED's

The present invention relates to the field of optic and electronic, and more particularly Organic Field Effect Transistors (OFETs), Organic Light Emitting Diodes (OLEDs) and

5      Organic Photovoltaic Cells (OPCs).

Organic conjugated oligomers and polymers are materials that possess a delocalized pi-electron system along their backbone. These organic materials are subject to important investigations from both academic and industrial laboratories due to their great potential

10     for applications in electronic and opto-electronic applications, such as field effect transistors (OFETs), light emitting diodes (OLEDs) and photovoltaic cells (OPCs). The economical advantages of using organic over inorganic semi-conducting materials in devices are the low cost of synthesis, ease of processing and the great tunability of their optical and electrical properties through chemical modifications.

15     The vast majority of microelectronic devices are currently based on crystalline silicon. For large area devices such as flat-panel displays and smart cards, where the use of crystalline silicon is limited by the size of the single crystals, amorphous and polycrystalline silicon are currently used. However, the relatively high temperatures needed in their fabrication process prevent their utilization with plastic substrates. While organic materials can be processed at room temperature by solution-processing or thermal evaporation on polymeric substrates, OFETs are gaining interest as their performance increases up to a point that they now compete with their inorganic counterparts. In the short term, it is recognized that organic semi-conductor materials could be used in the production of low-resolution components, such as identification tags, smart cards and pixel drivers for displays. Up to now, there are only pentacene and regioregular polythiophenes that have demonstrated the required performances, but the former is difficult to process and the later is easily oxidized in air.

30     On the other hand, it has long been felt that a technically viable emissive display technology could compete with the currently dominating technology of liquid crystal

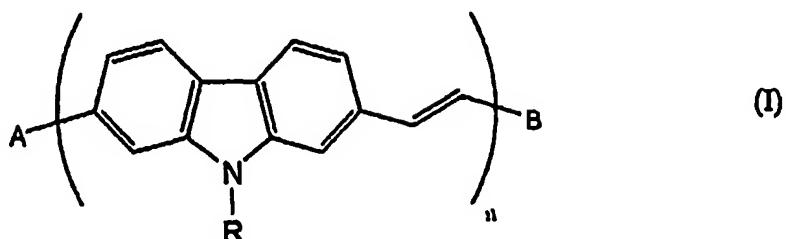
- displays (LCDs) and OLEDs are today considered in the best position to do just that. While the technology of LCDs present limitations such as low efficiency, poor vision angle, and speed and temperature range limitations, OLEDs are of particular promise for displays as they can be tuned to any color, operating at relatively low voltages with high efficiency and having excellent visual properties. A lot of work is going on in chemistry laboratories to find materials with high luminous quantum efficiency, good color purity and great stability for the application to OLED displays. While some materials meet or exceed some of the requirements for commercial displays, none meets them all.
- 5
- 10 The need to develop renewable energy sources continues to stimulate new approaches to the conversion of solar energy into electrical energy through the production of photovoltaic devices. Although inorganic semi-conductors such as silicon, amorphous silicon, gallium arsenide and sulfide salts, have been the primary focus of commercial applications, the photosensitivity and the photovoltaic effects in devices made with
- 15 conjugated oligomeric or polymeric organic materials have been also explored and have shown excellent results. The main advantage of using organic materials in photovoltaic devices is the low-cost of fabrication in large sizes and in desired lightweight shapes. As an example, the use of semi-transparent organic thin film on roof area or between insulating windows could be employed as power generation in crowded cities.
- 20
- Intense research is going on at the chemistry level to find a class of organic materials that could be used in OFETs as well as in OLEDs and OPCs. This new class of materials should be ease and low-cost of synthesis and should have great and ease tunability of their electrical and optical properties through chemical modifications to meet the entire
- 25 required criterions for commercialization of OLEDs, OFETs and OPCs.

#### SUMMARY OF THE INVENTION

According to the present invention there are provided an Organic Field Effect Transistor (OFET), an Organic Light Emitting Diode (OLED), and an Organic Photovoltaic Cell

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(OPC) comprising as their active material a conjugated 2,7-carbazolenevinylene derivative described by the formula (I):

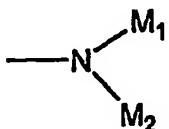


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wherein n is an integer  $\geq 3$ , R represents a substituent that is a hydrogen, or linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, poly(ethyleneoxy), cyano, aryl group, amide group or benzoyl group, and A, B are any type of end-cap groups.

10

For example, A and B end-cap groups can be selected from hydrogen, linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, cyano, fluoro, chloro, bromo, iodo, monovalent aromatic group, e.g. a phenyl, a naphthyl, and a anthryl group, or monovalent aromatic complex ring group having one nitrogen atom as a hetero-atom, e.g. a pyrropyl group, a pyridyl group, quinolyl group and a carbazolyl group. These aryl groups (aromatic groups) and aromatic complex ring groups may have, or need not have substituants. For example, substituants may be selected from a linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, acyl group, benzyl group, aryloxy group, alkoxy-carbonyl group, acyloxy group, acylamino group, halogen group, carboxyl group, hydroxy group, aminocarbonyl group, aryloxycarbonyl group, aryl group, and further amino group represented by the general formula:



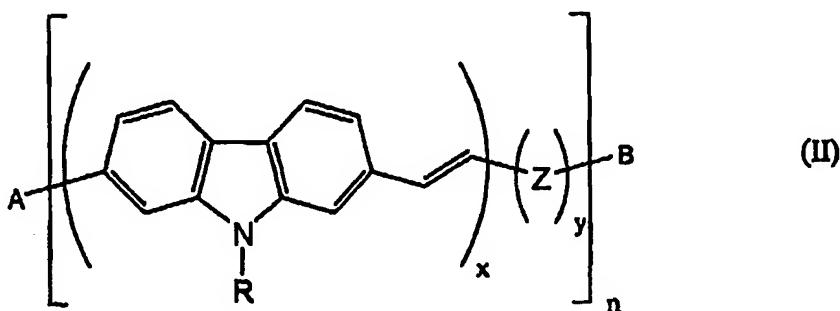
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wherein M<sub>1</sub> and M<sub>2</sub> are each an hydrogen atom, or linear or branched alkyl group, acyl group such as an aldehyde group, a formyl group, an acetyl group and a propyonyl group, aryl group and the like; M<sub>1</sub> and M<sub>2</sub> may be the same or different, and they may combine with each other to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant), and may combine with the substituants on A and B to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant).

In general formula (I), A and B may be the same or different, and the substituants on A 10 and B may combine with each other to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant).

2,7-carbazolenevinylene monomers can also be alternated with other monomers to form oligomeric or polymeric materials according to the general formula (II):

15

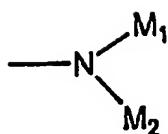


wherein n is an integer  $\geq 3$ , R represents a substituant that is a hydrogen, or linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group 20 containing 1 to 20 carbon atoms, poly(ethyleneoxy), cyano, aryl group, amide group or benzoyl group, x is an integer between 1 to 1000, y is an integer between 0 to 1000, Z is any type of comonomer, and A, B are any type of end-cap groups.

The conjugated oligomeric and polymeric 2,7-carbazolenevinylene derivatives comprise repeating or alternating units of the above formula (II). For example, the comonomers 25 can be selected from ethylene, acetylene, C<sub>6</sub>-C<sub>22</sub> mononuclear/polynuclear aromatic, C<sub>2</sub>-C<sub>10</sub> mononuclear/polynuclear heterocyclic groups and tertiary arylamines.

Examples of mononuclear/polynuclear aromatic group are: phenylene, fluorene, naphthalene, anthracene, tetracene, pyrene, perylene, rubrene, phenanthrene, naphthylene, acenaphthene, fluoranthene and chrysene. Examples of mononuclear/polynuclear heterocyclic internal groups include 5-member heterocyclic groups such as furan, thiophene, pyrrole, oxazole, isooxazole, oxadiazoles, thiazole, isothiazole, imidazole, thiadiazole and pyrazole; 6-member heterocyclic groups such as pyridine, pyridazine, pyrimidine, pyrazine, triazine and tetrazine; benzo-fused ring systems such as benzoxazole, benzothiazole, benzimidazole, quinoline, isoquinoline, cinnoline, quinazoline, quinoxaline, phthalazine, benzothiadiazole and benzotriazine; polynuclear fused condensed ring systems such as phenazine, phenanthridine, acridine and diphenylene oxide. Examples of tertiary arylamine groups include triphenylamine, N,N'-diphenylbenzidine, N,N'-diphenyl-1,4-phenylenediamine and diphenylnaphthylamine. Olefinic, aromatic, heterocycle and tertiary arylamines groups may be substituted optionally with one or more substituants. Examples of substituants include C<sub>1</sub>-C<sub>20</sub> linear or branched alkyl group, C<sub>1</sub>-C<sub>20</sub> linear or branched alkoxy group, cyano, fluoro, chloro, bromo, iodo, C<sub>1</sub>-C<sub>20</sub> linear or branched alkyloxycarbonyl, C<sub>1</sub>-C<sub>20</sub> linear or branched aryloxycarbonyl and poly (alkyleneoxy). Such substituants may be selected to improve the solubility or processing characteristics of the materials.

For example, A and B end-cap groups can be selected from hydrogen, linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, cyano, fluoro, chloro, bromo, iodo, monovalent aromatic group, e.g. a phenyl, a naphthyl, and a anthryl group, or monovalent aromatic complex ring group having one nitrogen atom as a hetero-atom, e.g. a pyrropyl group, a pyridyl group, quinolyl group and a carbazolyl group. These aryl groups (aromatic groups) and aromatic complex ring groups may have, or need not have substituants. For example, substituants may be selected from a linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, acyl group, benzyl group, aryloxy group, alkoxy-carbonyl group, acyloxy group, acylamino group, halogen group, carboxyl group, hydroxy group, aminocarbonyl group, aryloxycarbonyl group, aryl group, and further amino group represented by the general formula:



wherein M<sub>1</sub> and M<sub>2</sub> are each an hydrogen atom, or linear or branched alkyl group, acyl group such as an aldehyde group, a formyl group, an acetyl group and a propyonyl group, aryl group and the like; M<sub>1</sub> and M<sub>2</sub> may be the same or different, and they may combine with each other to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant), and may combine with the substituants on A and B to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant).

In general formula (II), A and B may be the same or different, and the substituants on A and B may combine with each other to form a saturated five-membered ring or a saturated six-membered ring (these rings may be with or without a substituant).

Oligomeric and polymeric carbazole derivative materials are a well-known class of materials. It has now been discovered how to synthesize highly conjugated poly (N-alkyl-2,7-carbazole) and have filed a patent application entitled "Conjugated Polycarbazole Derivatives and Process for the synthesis thereof" on their method of synthesis. The present invention provides, interalia, use of conjugated oligomeric and polymeric 2,7-carbazolenevinylene derivatives as the active material in OFETs, OLEDs, and OPCs.

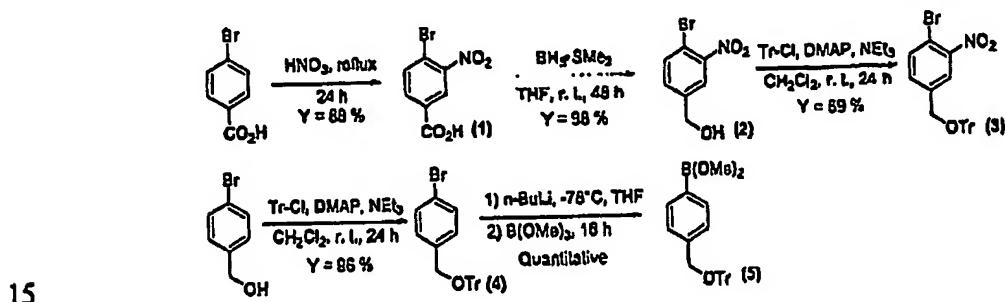
2,7-carbazolenevinylene compounds can be used in OFETs as the active p-type semi-conductor or n-type semi-conductor where holes or electrons are the majority carriers respectively, depending of the end-caps and side groups used.

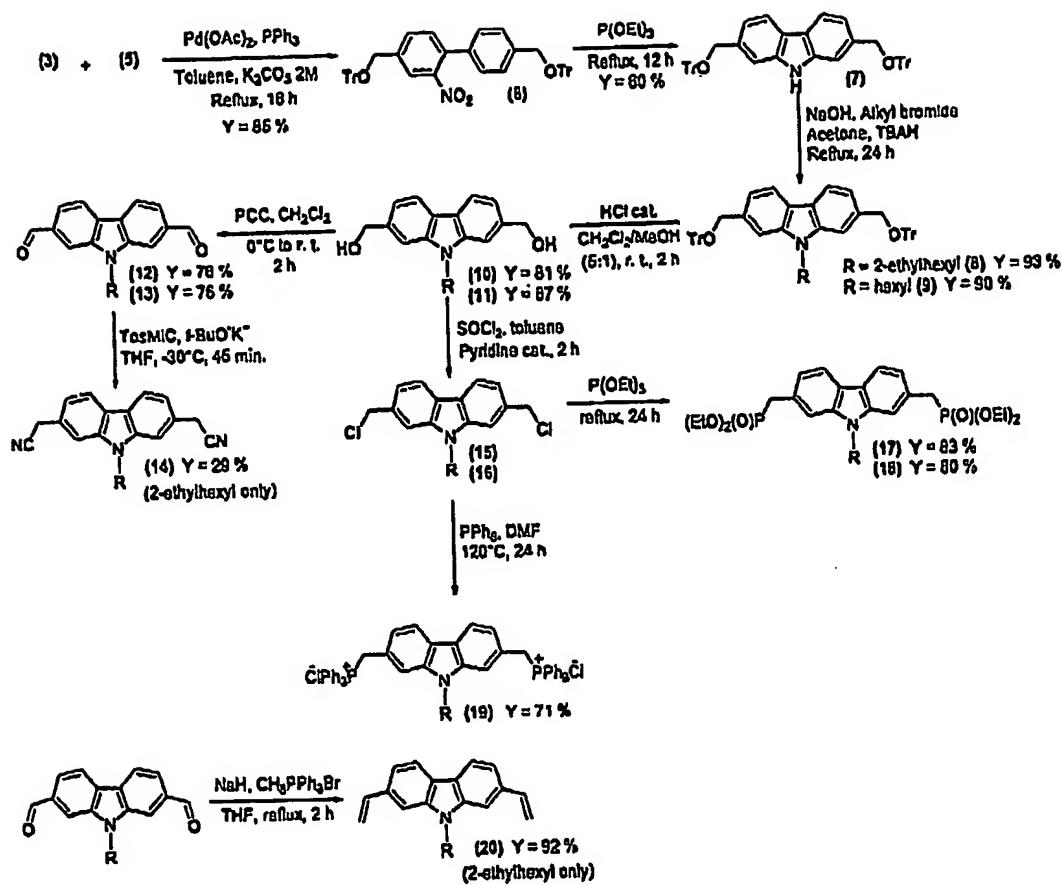
2,7-carbazolenevinylene compounds can be used in OLEDs as emitter, hole transport layers, electron transport layers or any combination of those roles depending of the end-caps and side groups used. They can be used either pure or blended or doped with other

hole or electron transport materials. They can also be used in multilayer arrangements to promote confinement or as an alternative to doping.

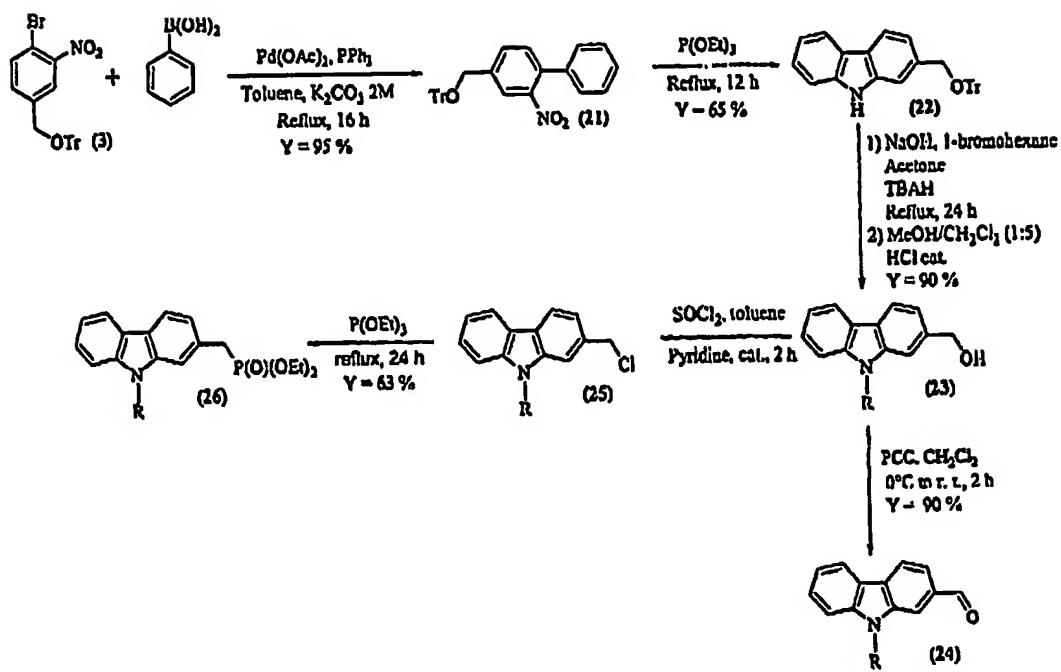
- 2,7-carbazolenevinylene compounds can be used in OPCs as absorption layers, free carrier generation layers, hole transport layers, electron transport layers or any combination of those roles depending of the end-caps and side groups used. They can be used either pure or blended or doped with other materials. They can also be used in multilayer arrangements to promote charge transfer process or as an alternative to doping.
- 5      Conjugated oligomeric and polymeric 2,7-carbazolenevinylene derivatives can be synthesized by the following route:

Scheme 1: Synthetic Route to 2,7-difunctionalized carbazole





Scheme 2: Synthetic Route to 2-functionnalized carbazole

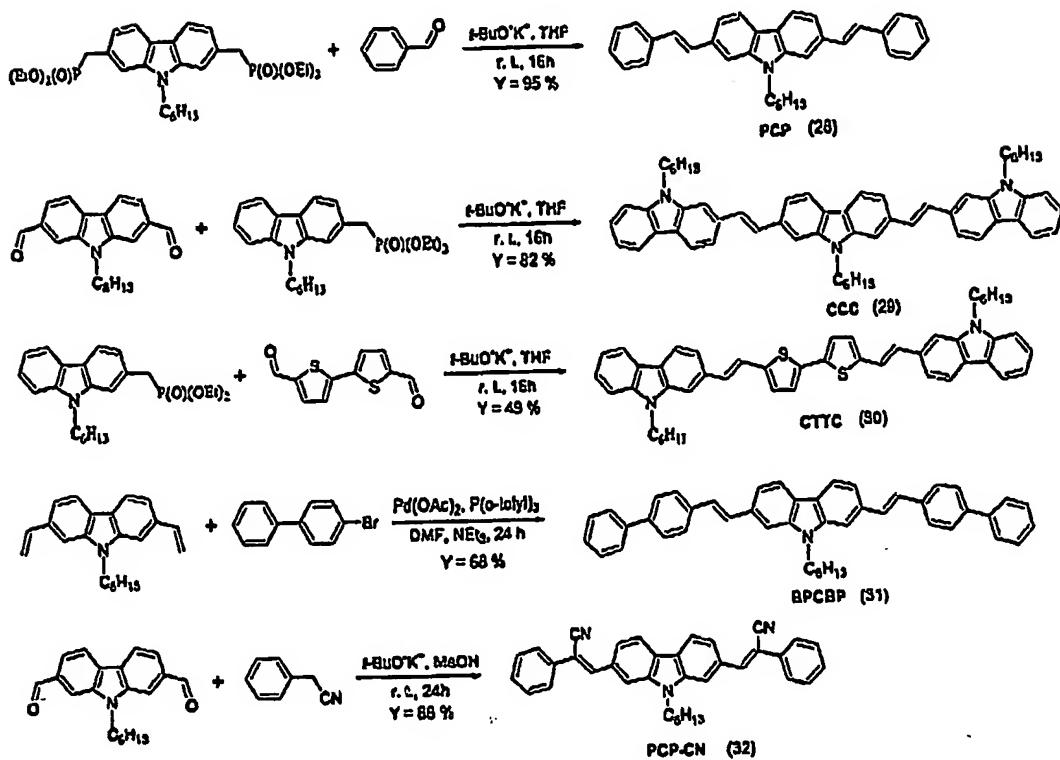


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Scheme 3: Synthetic Route to 2,7-carbazolenevinylene oligomers

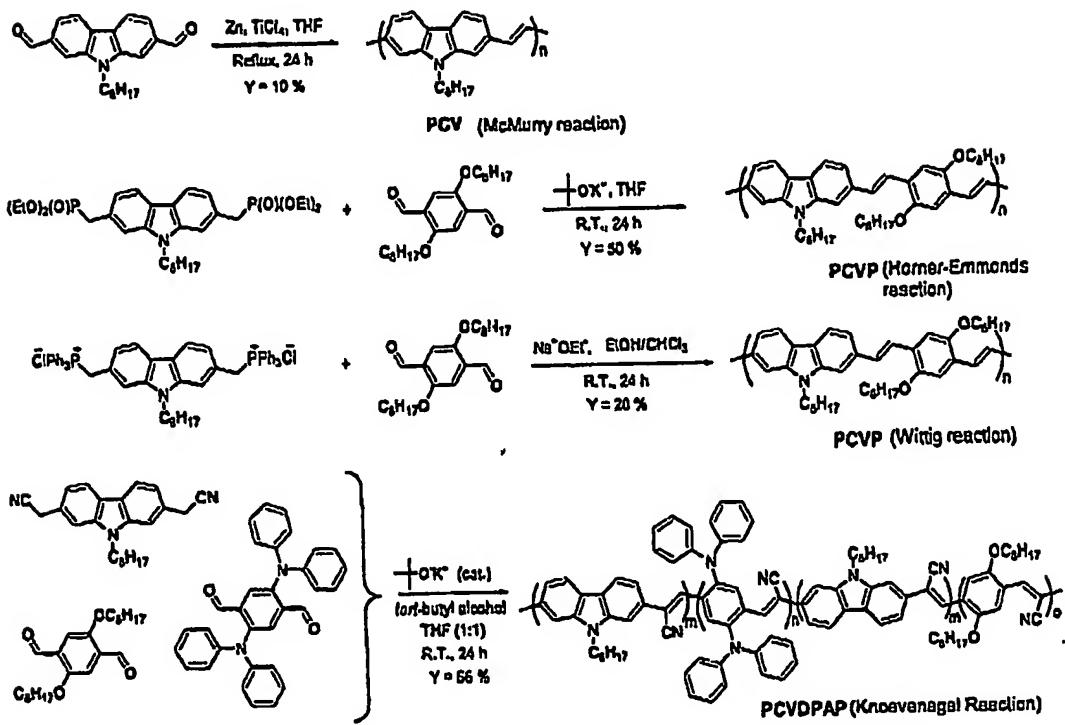


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Scheme 4: Synthetic Route to 2,7-carbazolenevinylene polymers



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The invention will now be described in more details, by way of non-limiting example  
5 only, with reference to the accompanying drawings, in which: -

Figure 1 shows a small-molecule field-effect transistor.

Figure 2 shows a polymer field-effect transistor.

10

Figure 3 shows a small-molecule light-emitting diode.

Figure 4 shows a polymer light-emitting diode.

15 Figure 5 shows a small-molecule photovoltaic cell.

Figure 6 shows a polymer photovoltaic cell.

Figure 7 shows an embodiment of the invention where an OFET is formed using CPC  
20 1,4-bis(vinylene-(N-hexyl-2-carbazole))phenylene thin film as the active semi-conductor  
in the (a) top contact or (b) bottom contact geometry;

Figure 8 shows the current-voltage characteristics of the embodiment of the transistor  
described in Figure 7 in the top contact geometry;

25

Figure 9 shows an embodiment of the invention where an OLED is formed using  
PCVDPAP [Poly (N-(2-ethylhexyl-2,7-carbazolenecyanovinylene-co-2,5-  
bis(diphenylamine)-1,4-phenylenecyanovinylene-co-2,5-diocyloxy-1,4-  
phenylenecyanovinylene)] thin film as emitter. The diode consists of an Indium Tin  
30 Oxide transparent conductive anode on a glass substrate, PCVDPAP as the emitter and a  
Ca cathode;

Figure 10 shows the electroluminescence spectrum of the diode described in Figure 9;

Figure 11 shows the current-voltage (curve 1) and luminescence-voltage (curve 2)

5 characteristics of the diode described in Figure 9;

Figure 12 shows an embodiment of the invention where an OLED is formed using PCCVP [Poly (N-(2-ethylhexyl)-2,7-carbazolenecyanovinylene-*alt*-2,5-dioctyloxy-1,4-phenylenevinylene)] thin film as the emitter. The diode consists of an Indium Tin Oxide  
10 transparent conductive anode on a glass substrate, a thin PEDOT-PSS [Poly (ethylene dioxythiophene: polystyrene sulfonate)] layer to promote hole injection, PCCVP as the emitter, Bu-PBD (2-(4-biphenyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole) as the electron transport layer, a thin LiF layer to promote electron injection and an Al cathode;

15 Figure 13 shows the electroluminescence spectrum of the embodiment of the diode described in Figure 12;

Figure 14 shows the current-voltage (curve 1) and luminescence-voltage (curve 2)  
characteristics of the diode described in Figure 12;

20 Figure 15 shows an embodiment of the invention where an OPC is formed using PCVDPATA [Poly (N-(2-ethylhexyl-2,7-carbazolenevinylene-co-2,5-bis(diphenylamine)-1,4-phenylenevinylene-co-((4-(2-ethylhexyloxy)-phenyl)-bis-(4'-phenylene)amine)] mixed with PTD [N,N'-Bis(2,6-dimethylphenyl)-3,4,9,10-perylenetetracarboxylic diimide] as the absorbing and the transporting layer. The  
25 photovoltaic cell consists of an Indium Tin Oxide transparent conductive anode on a glass substrate, PCVDPATA: PTD (20:80) as the absorbing layer and an Al cathode; and

Figure 16 shows the current-voltage characteristics in dark and under illumination of the  
30 embodiment of the photovoltaic cell described in Figure 15.

- The device shown in Figure 1 consists of a n-type silicon wafer covered with a thermally grown  $\text{SiO}_2$  film used as substrate, two gold electrodes (source and drain) on top of the substrate, a third electrode (gate) on the back side of the substrate, a thin (NiPc) nickel phthalocyanine layer, and a thin (ScPc) scandium phthalocyanine layer. When a sufficiently high negative voltage is applied to the gate, an inversion layer forms at the insulator/semi-conductor interface and positive charges are created. Varying the applied voltage at the gate, the negative current between the source and drain through the diphthalocyanine layer is modulated.
- 5
- 10 The device shown in Figure 2 consists of a n-type silicon wafer covered with a thermally grown  $\text{SiO}_2$  film used as substrate, two gold electrodes (source and drain) on top of the substrate, a third gallium-indium electrode (gate) on the back side of the substrate, and a thin PT (polythiophene) layer. When a sufficiently high negative voltage is applied to the gate, an inversion layer forms at the insulator/semi-conductor interface and positive charges are created. Varying the applied voltage at the gate, the negative current between the source and drain through the PT layer is modulated.
- 15
- 20 The device shown in Figure 3 consists of an Indium Tin Oxide transparent anode on a glass substrate, an aromatic diamine as the hole transport layer, an  $\text{AlQ}_3$  (8-hydroxyquinoline aluminum) electron transport and emitter layer, and an Mg:Ag alloy cathode. When a sufficiently positive voltage is applied between the anode and the cathode, holes are injected from the anode, electrons are injected from the cathode and they recombine radiatively in the  $\text{AlQ}_3$  emissive layer, producing light that is seen through the transparent anode and hole transport layer.
- 25
- 30 The device shown in Figure 4 consists of an Indium Tin Oxide transparent anode on a glass substrate, a thin PPV (poly(p-phenylenevinylene)) layer, and an Al cathode. When a sufficiently high positive voltage is applied between the anode and the cathode, holes are injected from the anode, electrons are injected from the cathode and they recombine radiatively in the PPV emissive layer, producing light that is seen through the transparent anode.

The shown in Figure 5 consists of an Indium Tin Oxide transparent anode on a glass substrate, a thin CuPc (copper pthalocyanine) layer, a thin PV (perylene tetracarboxylic) layer, and an Ag cathode. Under illumination through the transparent Indium Tin Oxide anode, charges are produced. When a sufficiently positive voltage is applied between the anode and the cathode, the photogenerated charges are transported and transferred to the electrodes.

The device shown in Figure 6 consists of an Indium Tin Oxide transparent anode on a glass substrate, a thin PPV (poly(p-phenylenevinylene)) layer, and an Al cathode. Under illumination through the transparent Indium Tin Oxide anode, charges are produced in PPV. When a sufficiently positive voltage is applied between the anode and the cathode, the photogenerated charges are transported and transferred to the electrodes.

## 15 FIRST EXAMPLE

In an embodiment of the invention shown in Figure 7, an OFET was fabricated in the top contact geometry consisting on a p-type silicon wafer covered with a thermally grown SiO<sub>2</sub> film used as substrate, a thin CPC semi-conductor layer, a source and drain gold electrode on top of the organic semi-conductor layer, and a gate electrode on the back side of the substrate. Prior to use, each substrate (15 x 15 mm<sup>2</sup>) is cleaned sequentially with acetone, ultrasonicated isopropanol at 60°C, and UV/ozone cleaner for 10 min. Then, the surface of the substrate was treated with hexamethyldisilazane (HMDS) on a vapor prime system at 150°C and 30 mmHg for 2 h prior to evaporation. In order, the organic semi-conductor CPC and gold are deposited by thermal evaporation at a pressure of 1 x 10<sup>-7</sup> torr at a substrate temperature of 195°C for CPC and 25°C for gold. The gold source and drain electrodes are deposited on top of the organic semi-conductor through a shadow mask forming a top contact geometry with a channel length of 40 μm and a channel width of 1 μm. An electrical wired bounding on the backside of the p-doped silicon wafer forms the gate electrode.

The transistor produces the current-voltage characteristics shown in Figure 8. It is shown that CPC forms a typical p-channel transistor operating in two different modes, which are the linear regime where the current follows Ohm's law at low source-drain voltage and the saturation regime as the source-drain voltage increase. In the conditions described above, CPC shows a high mobility of  $1.2 \times 10^{-2} \text{ cm}^2/\text{V}$  and a high  $I_{on}/I_{off}$  ratio of  $10^6$ .

5

## SECOND EXAMPLE

In an embodiment of the invention, shown in Figure 9, an OLED was fabricated  
10 consisting of an Indium Tin Oxide transparent conductive anode on a glass substrate, a thin PCVDPAP layer as emitter, and a Ca cathode. The Indium Tin Oxide coated glass ( $5 \times 5 \text{ cm}^2$ ) with a sheet resistance of 15 ohm/sq is patterned using photolithography technique to produce ten segments each with active area of  $5 \times 6 \text{ mm}^2$ . Prior to use, the substrates are cleaned sequentially with detergent, deionized water, acetone,  
15 ultrasonicated isopropanol at  $60^\circ\text{C}$ , and UV/ozone cleaner for 10 min. The polymeric PCVDPAP material is solubilized in chloroform, filtered through  $0.2 \mu\text{m}$  PTFE filter, spin-coated at 2000 rpm for 60 s onto the Indium Tin Oxide substrate, and dried at  $40^\circ\text{C}$  for 10 min. Ca layer is thermally evaporated at a pressure of  $1 \times 10^{-7}$  torr and at room temperature.

20

The diode produced the electroluminescence spectrum shown in Figure 10. The resulting diode emitted orange-red light with peak emission around 660 nm. No emission of an excimer is observed (no emission peak at higher wavelengths). The current-voltage (curve 1) and luminescence-voltage (curve 2) characteristics of the diode are shown in  
25 Figure 11. In the device configuration described above, the maximum luminescence value that has been obtained is  $150 \text{ cd/m}^2$  at 18 V with a low turn-on device voltage of 3 V.

### THIRD EXAMPLE

In an embodiment of the invention shown in Figure 12, an OLED was fabricated consisting of an Indium Tin Oxide transparent conductive anode on a glass substrate, a thin PEDOT-PSS layer to promote hole injection, a thin PCCVP layer as emitter, Bu-PBD as the electron transport layer, a thin LiF layer to promote electron injection, and an Al cathode. The Indium Tin Oxide coated glass ( $5 \times 5 \text{ cm}^2$ ) with a sheet resistance of 15 ohm/sq is patterned using photolithography technique to produce ten segments each with active area of  $5 \times 6 \text{ mm}^2$ . Prior to use, the substrates are cleaned sequentially with detergent, deionized water, acetone, ultrasonicated isopropanol at  $60^\circ\text{C}$ , and UV/ozone cleaner for 10 min. The thin PEDOT-PSS (Baytron P CH 8000, Bayer/Germany) layer is first spin-coated at 5000 rpm for 60 s from its water solution (2.8 wt %) onto the Indium Tin Oxide substrate, and dried at  $120^\circ\text{C}$  for 1 h. The polymeric PCCVP material is solubilized in chloroform, filtered through 0.2  $\mu\text{m}$  PTFE filter, spin-coated at 2000 rpm for 60 s, and dried at  $40^\circ\text{C}$  for 10 min. Bu-PBD, LiF and Al layers are thermally evaporated at a pressure of  $1 \times 10^{-7}$  torr and at room temperature.

The diode produced the electroluminescence spectrum shown in Figure 13. The resulting diode emitted orange-red light with peak emission around 636 nm. The electroluminescence is thus originating from PCCVP itself. No emission of an excimer is observed (no emission peak at higher wavelength). The current-voltage (curve 1) and luminescence-voltage (curve 2) characteristics of the diode are shown in Figure 14. In the device configuration described above, the maximum luminescence value that has been obtained is 122 cd/m<sup>2</sup> at 20 V with a low turn-on device voltage of 3 V.

25

### FOURTH EXAMPLE

In an embodiment of the invention shown in Figure 15, an OPC was fabricated consisting of an Indium Tin Oxide transparent conductive anode on a glass substrate, a blend of PCVDPATA and PTD (20:80) as the absorbing and transporting layer, and an Al cathode. The Indium Tin Oxide coated glass ( $25 \times 25 \text{ mm}^2$ ) with a sheet resistance of 20

ohms/sq is patterned using lithography technique to produce one segment with active area of 10 mm<sup>2</sup>. Prior to use, the substrates were cleaned sequentially with detergent, deionized water, acetone and ultrasonicated isopropanol. The PCVDPATA: PTD (20:80) blend is solubilized in chloroform, filtered through 0,2 µm PTFE filter and spin-coated at 2000 rpm for 60 s. Al layer is thermally evaporated at a pressure of 1 x 10<sup>-6</sup> torr at room temperature.

The photovoltaic cell produced the current-voltage characteristics in dark and under illumination shown in Figure 16.

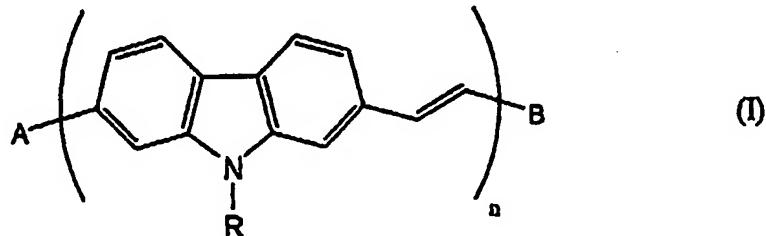
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It will be appreciated that, in light of the disclosure herein, one skilled in the art could employ the method disclosed herein to produce OLEDs and related devices from carbazolene derivatives in addition to the 2,7 derivatives described in the examples herein.

15

In an embodiment of the invention there is provided an Organic Field Effect Transistor (OFET), an Organic Light Emitting Diode (OLED), and an Organic Photovoltaic Cell (OPC) comprising active material including a conjugated oligomeric or polymeric 2,7-carbazolenevinylene derivative described by the formula (I):

20

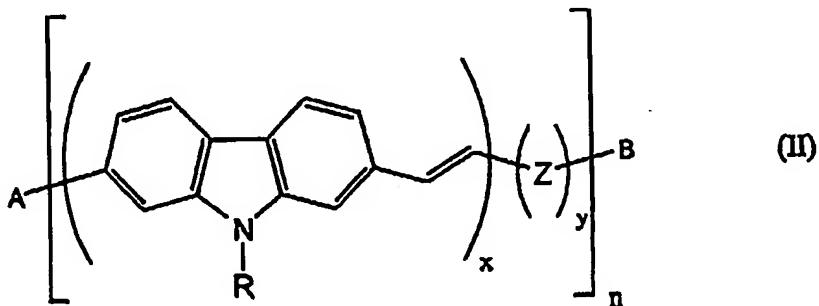


wherein n is an integer  $\geq 3$ , R represents a substituent that is a hydrogen, or linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, poly(ethyleneoxy), cyano, aryl group, amide group or benzoyl group, and A, B are any type of end-cap groups selected from the group consisting of hydrogen, linear or branched alkyl group containing 1 to 20 carbon atoms,

linear or branched alkoxy group containing 1 to 20 carbon atoms, cyano group, halogen group, monovalent aromatic group, and monovalent aromatic complex ring group having one nitrogen atom as a hetero-atom.

5

In an embodiment of the invention there is provided an Organic Field Effect Transistor (OFET), an Organic Light Emitting Diode (OLED), and an Organic Photovoltaic Cell (OPC) comprising active material including a conjugated 2,7-carbazolenevinylene derivative where 2,7-carbazolenevinylene monomers can also be alternated with other monomers to form oligomeric or polymeric materials according to the general formula (II):



15 wherein n is an integer  $\geq 3$ , R represents a substituent that is a hydrogen, or linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, poly(ethyleneoxy), cyano, aryl, amide or benzoyl, x is an integer between 1 to 1000, y is an integer between 0 to 1000, Z is any type of comonomer selected from the group consisting of ethylene, acetylene, C<sub>6</sub>-C<sub>22</sub> mononuclear/polynuclear aromatic, C<sub>2</sub>-C<sub>10</sub> mononuclear/polynuclear heterocyclic groups and tertiary arylamines, and A, B are any type of end-cap groups selected from the group consisting of hydrogen, linear or branched alkyl group containing 1 to 20 carbon atoms, linear or branched alkoxy group containing 1 to 20 carbon atoms, cyano group, halogen group, monovalent aromatic group, and monovalent aromatic complex ring group having one nitrogen atom as a hetero-atom.

In an embodiment of the invention there is provided an OFET, wherein said 2,7-carbazolenevinylene derivative is 1,4-bis(vinylene-(N-hexyl-2-carbazole))phenylene (CPC).

- 5 In an embodiment of the invention there is provided an OLED, wherein said 2,7-carbazolenevinylene derivative is [Poly (N-(2-ethylhexyl)-2,7-carbazolenecyanovinylene-co-2,5-bis(diphenylamine)-1,4-phenylenecyanovinylene-co-2,5-dioctyloxy-1,4-phenylenecyanovinylene)] (PCVDPAP).
- 10 In an embodiment of the invention there is provided an OLED, wherein said 2,7-carbazolenevinylene derivative is [Poly (N-(2-ethylhexyl)-2,7-carbazolenecyanovinylene-*alt*-2,5-dioctyloxy-1,4-phenylenevinylene)] (PCCVP).

- 15 In an embodiment of the invention there is provided an OLED, wherein said 2,7-carbazolenevinylene derivative is mixed with a second active material.

- 20 In an embodiment of the invention there is provided an OLED comprising a hole transport layer, an electron transport layer, and wherein at least one of said hole transport layer and said electron transport layer comprises either alone or in combination as active material a conjugated 2,7-carbazolenevinylene derivative.

- 25 In an embodiment of the invention there is provided an OLED, further comprising a carrier promotion layer adjacent at least one of said electron transport layer and said hole transport layer.

- 30 In an embodiment of the invention there is provided an OLED, wherein said electron promotion is LiF.

- 35 In an embodiment of the invention there is provided an OLED, wherein said hole promotion is [Poly (ethylene dioxythiophene: polystyrene sulfonate)] (PEDOT-PSS).

In an embodiment of the invention there is provided an OLED, wherein said hole promotion is [Poly (ethylene dioxythiophene: polystyrene sulfonate)] (PEDOT-PSS), said hole transport is [Poly (N-(2-ethylhexyl)-2,7-carbazolenecyanovinylene-*alt*-2,5-dioctyloxy-1,4-phenylenevinylene)] (PCCVP), said electron transport layer is Bu-PBD (2-(4-biphenylyl)-5-(4-tert-butylphenyl)-1,3,4-oxadiazole) and said electron promotion is LiF.

5 In an embodiment of the invention there is provided an OPC, wherein said 2,7-carbazolenevinylene derivative is [Poly (N-(2-ethylhexyl)-2,7-carbazolenevinylene-co-10 2,5-bis(diphenylamine)-1,4-phenylenevinylene-co-((4-(2-ethylhexyloxy)-phenyl)-bis-(4'-phenylene)amine)] (PCVDPATA).

In an embodiment of the invention there is provided an OPC, wherein said 2,7-carbazolenevinylene derivative is mixed with a second active material.

15 In an embodiment of the invention there is provided an OPC, wherein said second active material is [ $N,N'$ -Bis(2,6-dimethylphenyl)-3,4,9,10-perylenetetracarboxylic diimide] (PTD).

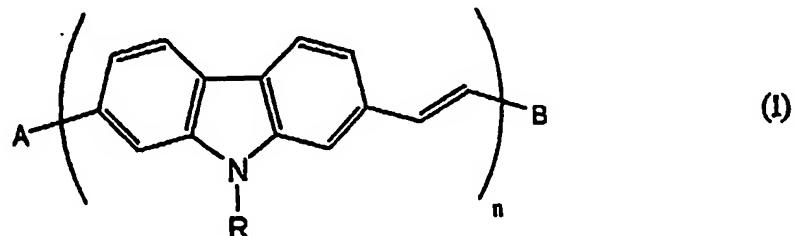
20 In an embodiment of the invention there is provide an OPC comprising a hole tranport layer, an electron transport layer, and wherein at least one of said hole transport layer and said electron transport layer comprises either alone or in combination as active material a conjugated 2,7-carbazolenevinylene derivative.

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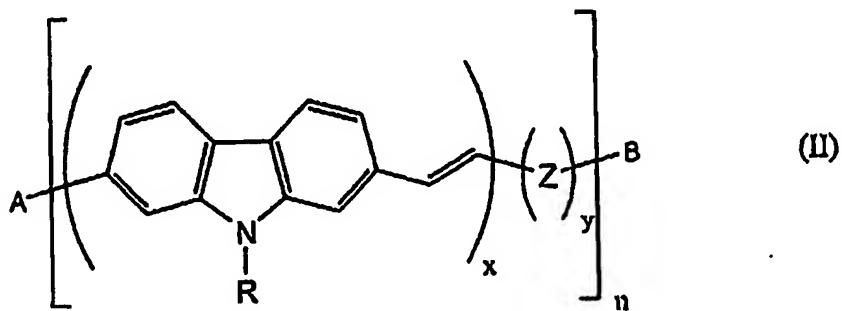
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## ABSTRACT OF THE DISCLOSURE

Organic Field Effect Transistor (OFET), an Organic Light Emitting Diode  
5 (OLED), an and an Organic Photovoltaic Cell (OPC) including as active material a  
conjugated oligomeric or polymeric 2,7-carbazolenevinylene derivative described by the  
formula (I) or (II):



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Such OFETs, OLEDs and OPCs have improved devices properties and efficiencies.

15

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Figure 1 (prior art):

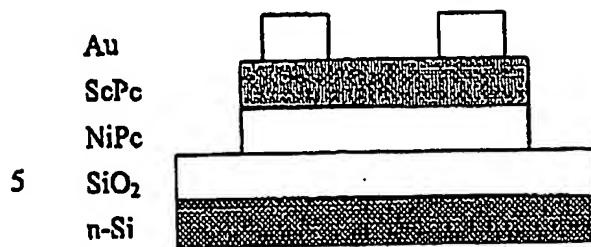
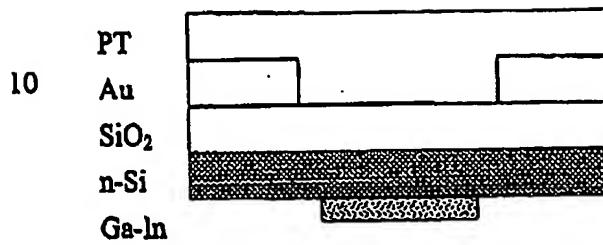
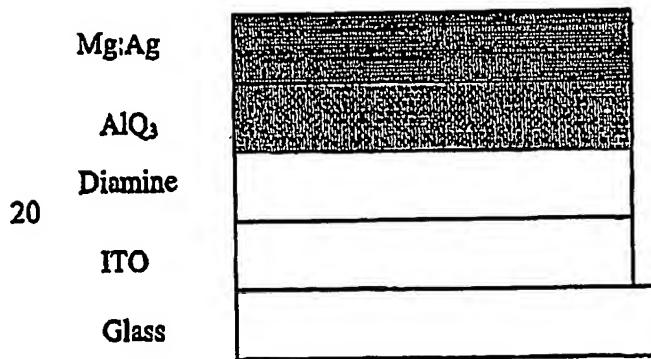


Figure 2 (prior art):



15 Figure 3 (prior art):



25 Figure 4 (prior art):

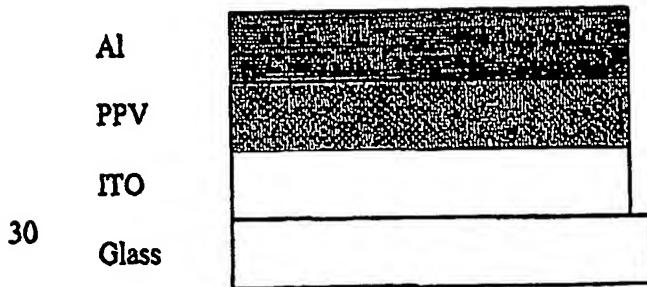
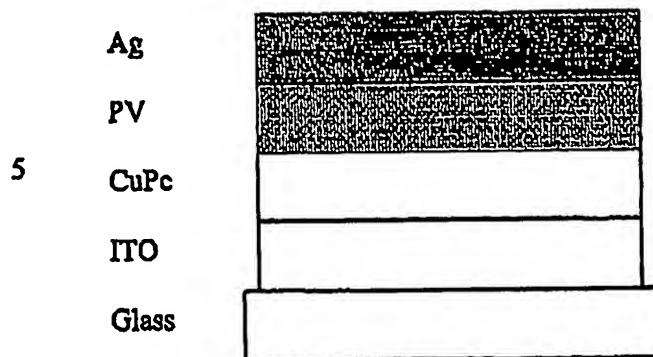
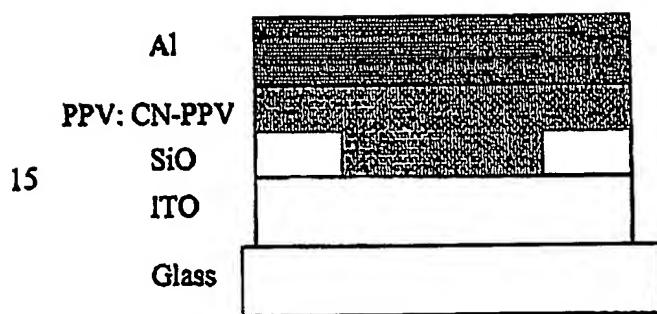


Figure 5 (prior art):



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Figure 6 (prior art):



20 Figure 7:

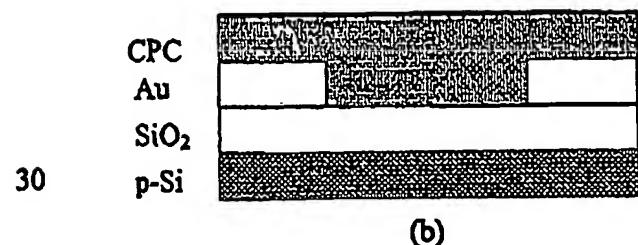
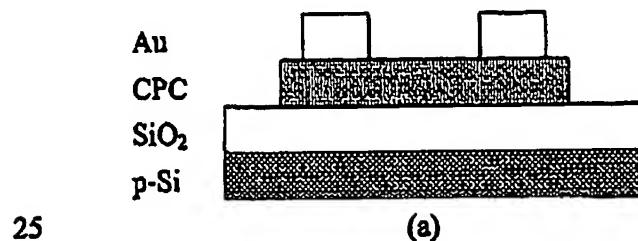
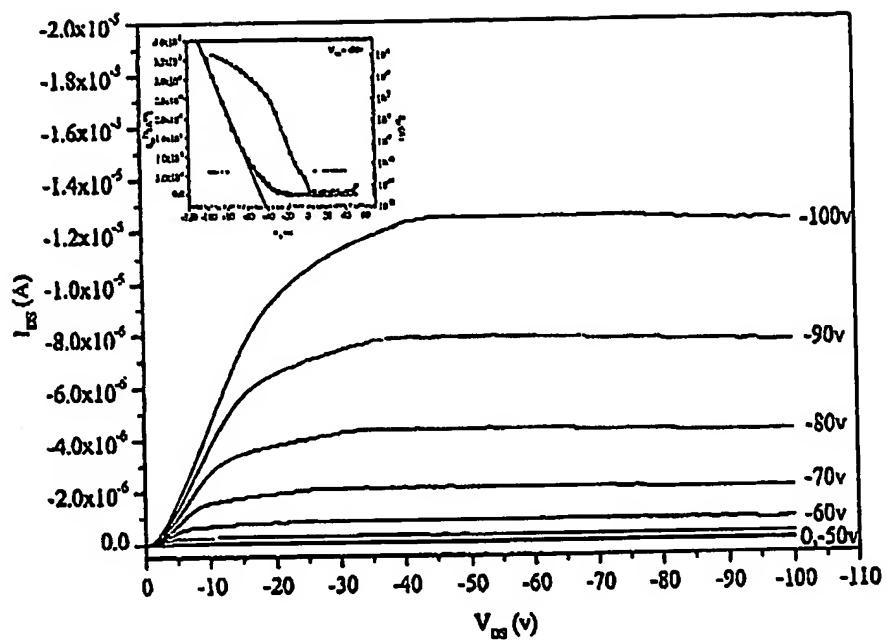


Figure 8:



5 Figure 9:

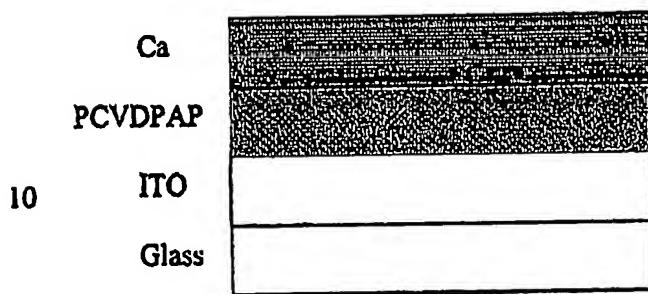


Figure 10:

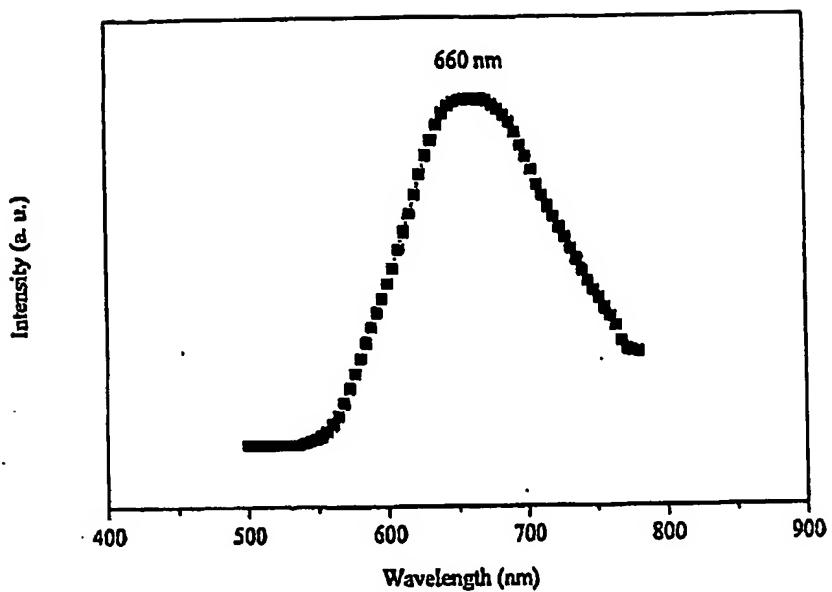


Figure 11:

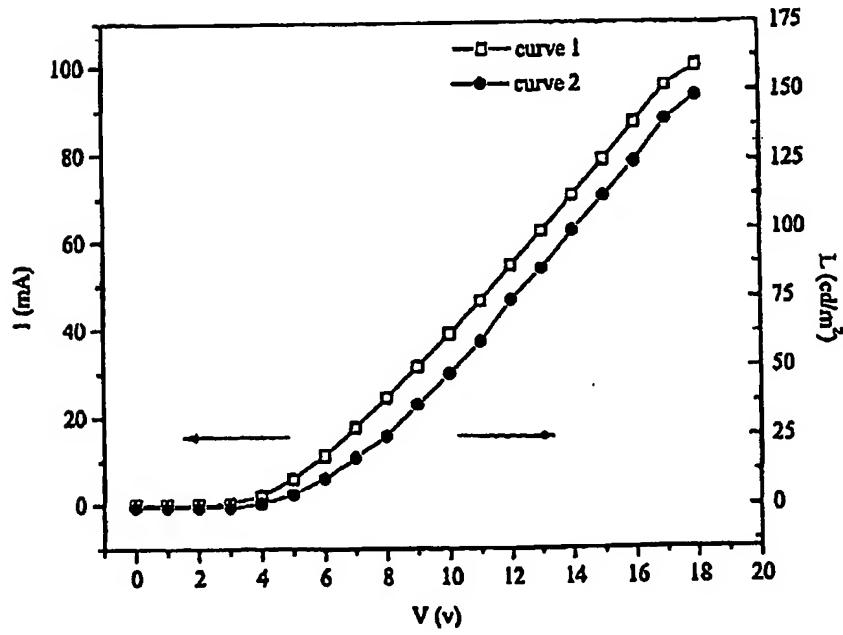


Figure 12:

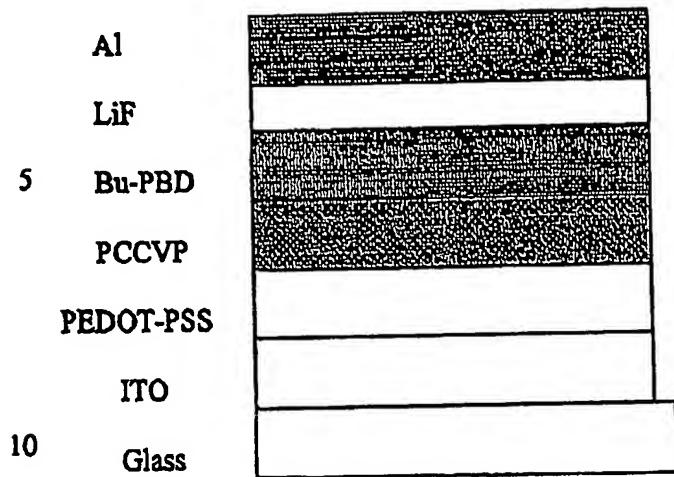
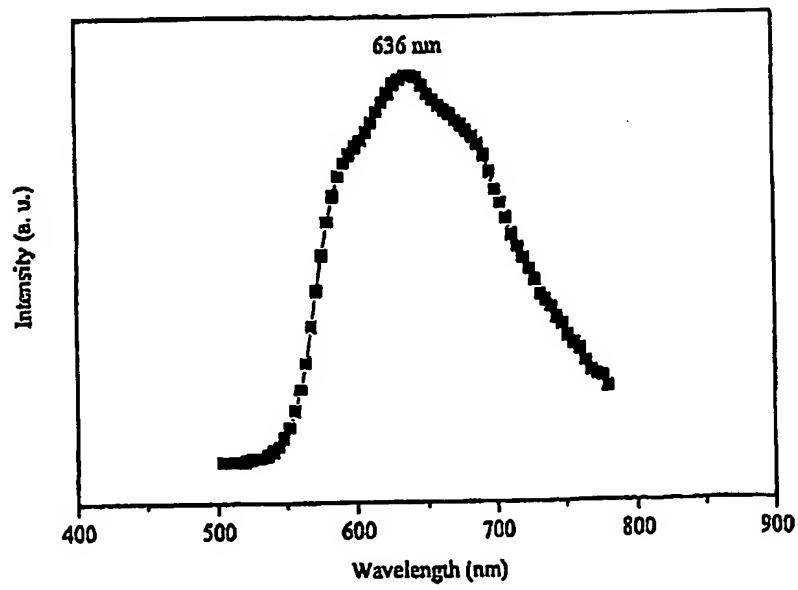
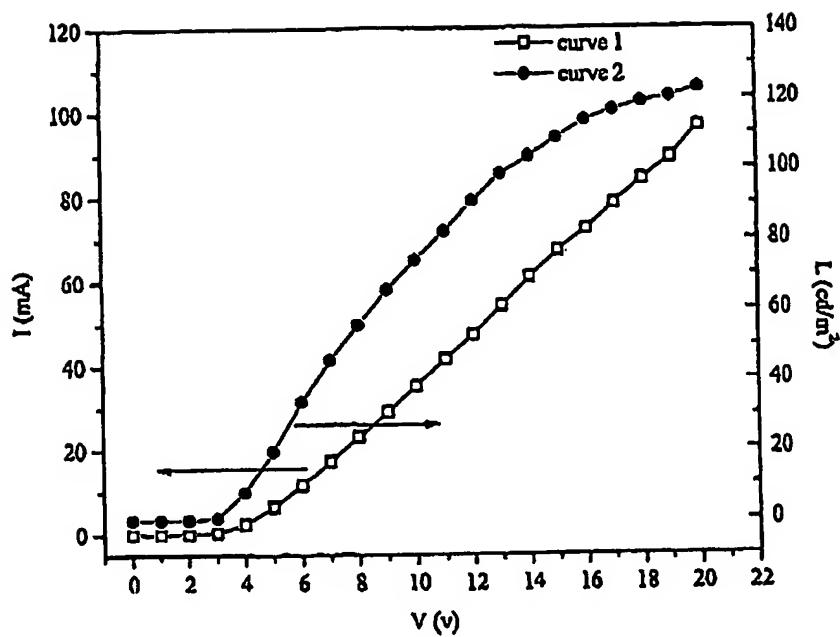


Figure 13:



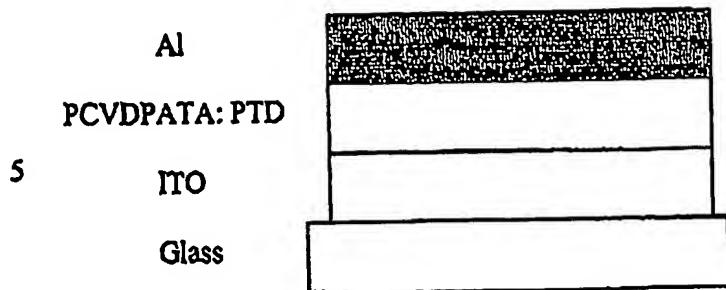
**Figure 14:**

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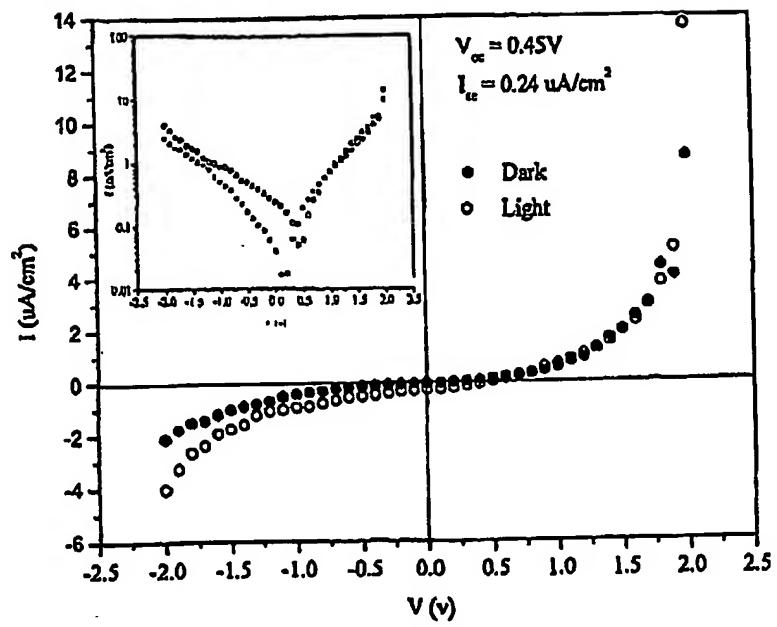
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Figure 15:



10 Figure 16 :



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